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Upper Extremity Injuries in the U.S. Military during Peacetime Years and Wartime Years

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INTRODUCTION

As of July 31, 2007, over one million Service Members (SMs) have been deployed to Iraq or Afghanistan. Approximately 29,000 of those deployed have been wounded in combat.[1] Of those, approximately 20,000 returned to duty, whereas 9,000 SMs presented with an injury severe enough to warrant a medical evacuation out of the theater of operation.[1] The military medical system has not had to manage this large number of casualties since the Vietnam War.[2] In this current war, weapon systems have become more sophisticated yet advances in personal protective equipment and medical care has demonstrated effectiveness by decreasing fatalities.

The SMs dying from combat wounds have declined since the United States started engaging in wars. In World War II, 30% of American Soldiers injured in combat died; this statistic decreased to 24% during the Vietnam conflict and further decreased to 10% during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), resulting in the current statistic of a 90% survival rate.[2,3] This high rate of survival is attributed to many factors such as improved individual body armor,[4–6] more accessible and improved surgical care on the battlefield,[7] and prompt evacuation of the wounded to major medical centers.[8] As demonstrated by the survival rate, these factors are proven to be successful; however, the successes are creating other challenges, specifically for the rehabilitation provider. The SMs are surviving combat-related wounds but are experiencing more complex injuries to their lower and upper extremities (UE). For example, in 2004, approximately 35% of troops wounded in combat during OIF and OEF had trauma to their extremities, compared to 4% who experienced trauma to their torso.[9]

Since the start of OIF and OEF, the UE injuries treated by occupational therapists (OT) have shifted. During peacetime, the diagnoses commonly treated by OT were sports-related. Most occupational therapy evaluations and treatments focused on straightforward, noncomplicated UE injuries such as finger dislocation, tendonitis, or routine UE surgical procedures such as carpal tunnel releases or internal/external fixation of fractures. Currently, SMs are presenting to occupational therapy clinics with

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complex and multiple UE injuries. The extensive and complicated surgical procedures that coincide with these injuries challenge the OT to provide new and innovative functional interventions.

Many studies have investigated injuries in the military. Some have investigated musculoskeletal injuries and reported that musculoskeletal injuries are the most prevalent source of disability in the U.S. Army, Navy, and Air Force,[10,11] account for the greatest number of outpatient visits,[12,13] and attribute to a significant portion of lost duty time.[14,15] Other studies investigated various types of injures, yet focused on specific populations such as basic trainees,[14,16–20] officer trainees,[21] or specific military units, namely infantry.[22,23] However, these studies were conducted before the start of OIF and OEF. The wartime studies currently being conducted typically address overall wounding patterns,[24] or specific diagnoses[25] with a greater focus on the lower extremity.

Although UE injuries are associated with not only medical, but also financial, psychological, and social consequences,[26] there is relatively little information available on UE injuries in the U.S. military during peacetime and during wartime. Individuals with UE injuries and disabilities have more difficulty in daily tasks such as writing, gripping, chores, opening jars, child care, carrying bags, bathing, and driving.[27] Upper extremity injuries and disabilities can negatively alter the SM's activities of daily living, leisure participation, and military duty performance and are proven factors that negatively affect military duty readiness and moral.[28]

The types of UE injuries and how the injuries may be changing with the current war efforts and the direct and indirect costs associated with these disorders need to be identified and defined before educational and intervention programs focusing on work reintegration, injury prevention, and health promotion can be developed. Thus, the purpose of this study is to characterize and subsequently improve the understanding of UE injuries in the U.S. military between 1998 and 2006 and, to compare them across branches of service. Specifically, this paper will compare and contrast the injury patterns during peacetime (1998–2001) and wartime (2002–2006) years. Determining the extent and nature of these injuries across the U.S. military will consequently provide guidance for researchers and policy makers in program development. It will also assist military educators in developing and modifying educational courses and curriculum focusing on the existing clinical environment. In addition, the results of this study may increase overall awareness of the extent of UE injuries occurring during combat. This in turn may assist military commanders and training officers in developing relevant training programs related to the prevention of UE injuries and the battlefield treatment of such injuries.

METHODS

The Institutional Review Board at the U.S. Army Research Institute of Environmental Medicine reviewed and approved this study protocol. This epidemiological retrospective investigation used data from a preexisting medical surveillance database to obtain a more precise picture of common UE diagnoses in the military and specifically in the different branches of service (i.e., Army, Air Force, Navy, and Marines), from 1998 to 2006. Ambulatory visits were the primary type of data examined and diagnostic categories were identified. The years were divided into peacetime, years 1998–2001, and wartime, years 2002–2006.

Defense Medical Epidemiology Database

The Defense Medical Epidemiology Database (DMED, version 3.6.4) is a database that allows access to subsets of the Defense Medical Surveillance System (DMSS). The DMSS is prepared by the Army Medical Surveillance Activity (Aberdeen Proving Ground, MD) and is an information system that contains up-to-date and historical data related to medical events (e.g., hospitalizations and outpatient visits) and personal characteristics (e.g., age, gender, race, and rank). The Army Medical Surveillance Activity manages DMSS for the purpose of maintaining longitudinal data on personnel in the military and is used to collect, integrate, and analyze military personnel and medical event data from all branches of service.[29]

The DMED allows users to access data relevant to active duty SMs: demographic, inpatient hospitalization, and medical ambulatory data. Demographic data such as age, gender, race, marital status, and rank are provided monthly by the Defense Manpower Data Center.[29] Hospitalization data are a subset of information from the Standard Inpatient Data Record (SIDR), which records inpatient treatment data. The SIDR data are collected by the Composite Health Care System, which is used in Department of Defense military treatment facilities around the world. For each hospitalization of an active duty SM diagnoses are recorded using the International Classification of Diseases, 9th Revision (ICD-9) code.[29] Ambulatory data are provided by the Executive Information and Decision Support Program Office. These data are a subset of information from the Standard Ambulatory Data Record, which records outpatient treatment data generated by the Medical Treatment Facilities and the outsourced, non–Department of Defense clinic outpatient health care provided to active duty SMs.[29] Diagnoses are recorded using the ICD-9 code for each outpatient visit by an active duty SM.

Data queries in DMED can be made according to demographic characteristics, branch of service (i.e., Army, Navy, Air Force, Marines, or all services), and/or ICD-9 diagnostic codes. Demographic characteristics include gender, age group, rank, race, and marital status. Gender is either male or female. Age groups within DMED are categorized as <20, 20–24, 30–34, 35–39, and >40 years. Ranks are grouped from E1 (Private) to E4 (Specialist) and E5 (Sergeant) to E9 (Sergeant Major or Command Sergeant Major) for enlisted personnel. The categories for officers are O1 (Second Lieutenant or Warrant Officer) to O3 (Captain or Warrant officer) and O4 (Major) to O9 (Four Star General). Race is divided into white, black, and other. Marital Status is reported as single, married, and other.

Data Extraction and Analysis

Demographics to include gender, age group, race, and service (Army, Air Force, Navy, and Marines) of the military population during the years 1998–2006 were obtained from the DMED database (Table 1). Data from 2007 were available but were excluded as the information is incomplete. The focus of the present investigation was to characterize and compare UE injuries commonly treated by OT during peacetime and wartime. Thus, common UE diagnostic categories and specific diagnoses commonly treated by OT were identified (Table 2). Crude ambulatory rates based on the identified ICD-9 UE diagnostic categories and codes for each individual service were extracted from the DMED database. Years were categorized into peacetime, 1998–2001 and wartime, 2002–2006. Unpaired t-tests were conducted on the identified ICD-9 codes for the total military and for each branch of service within the military to investigate any significant differences between the UE diagnoses reported during peacetime and the UE diagnosis reported during wartime. All analyses were performed using the statistical package SPSS version 15.0 (SPSS, Chicago, IL).

RESULTS

The average number of SMs in the military from 1998 to 2006 was approximately 1,539,081; 35% were in the Army, 26% in the Air Force, 27% in the Navy, and 12% in the Marines (Table 1). During this time period, the incidence of the 20 most common UE ICD-9 diagnoses identified in this investigation increased 3% across all branches of the military. The most prevalent UE injuries in the military during this time period were UE fractures (4.5%) and UE strains/sprains (4.5%).

Grouping the data into peacetime years (1998–2001) and wartime years (2002–2006) and conducting unpaired t-test revealed that during the wartime years, there were significant increases in several diagnoses across all branches of military service. There was a 47% increase in amputations ($p < 0.037$), 89% in brachial plexus lesions ($p < 0.010$), 98% in burns ($p < 0.013$), 129% in lesion of the radial nerve ($p < 0.006$), and 52% in lesion of the ulnar nerve ($p < 0.008$). In contrast, enthesopathy of the elbow was reported more during the peacetime years ($p < 0.029$) (Figure 1).

Further analyses of each individual military service (i.e., Army, Air Force, Navy, and Marines) revealed that in the Army there were significant increases during wartime compared to peacetime.

TABLE 1. **Average Demographics of the Total Population Divided into Peacetime Years from 1998 to 2001 and Wartime Years from 2002 to 2006**

	Military		*Army*		*Air Force*		*Navy*		*Marines*	
	Peace	*War*	*Peace*	*War*	*Peace*	*War*	*Peace*	*War*	*Peace*	*War*
% of Population	100.00	100.00	34.42	35.12	26.04	25.88	27.09	26.31	12.45	12.68
Gender										
Male (%)	85.81	85.20	85.04	85.26	81.75	80.43	86.79	85.58	94.27	93.96
Female (%)	14.19	14.80	14.96	14.74	18.25	19.57	13.21	14.42	05.73	06.04
Age										
<20 (%)	08.58	07.80	08.62	07.45	05.86	05.60	08.21	07.17	14.94	14.61
20–24 (%)	30.92	34.02	30.73	33.30	25.17	29.60	29.65	33.04	46.27	47.06
25–29 (%)	20.50	20.62	22.42	21.42	19.90	21.14	20.44	20.72	16.55	17.11
30–34 (%)	15.96	14.37	16.45	15.43	18.07	14.87	16.31	14.74	09.45	09.60
35–39 (%)	14.54	12.67	12.88	12.52	19.05	15.07	15.33	13.31	07.96	06.88
≥40 (%)	09.50	10.52	08.89	09.88	11.96	13.72	10.06	11.03	04.83	04.75
Race										
White (%)	70.50	70.29	62.60	66.09	77.79	76.02	71.72	67.83	74.50	75.48
Black (%)	20.70	19.28	27.33	24.02	15.90	15.63	18.99	19.58	16.05	12.93
Other (%)	08.80	10.43	10.07	09.89	06.31	08.35	09.29	12.59	09.45	11.59
Rank										
Enlisted (%)	84.01	83.83	83.67	83.65	80.33	79.92	85.44	85.25	89.57	89.39
Officer (%)	15.99	16.17	16.33	16.35	19.67	20.08	14.56	14.75	10.43	10.61

TABLE 2. **Upper Extremity Diagnostic Categories and Codes Commonly Treated by Military OTs**

ICD-9 Code	*Description*
353.0	Brachial plexus lesion
354.0	Carpal tunnel syndrome
354.2	Lesion of ulnar nerve
354.3	Lesion of radial nerve
726.1	Rotator cuff syndrome of shoulder and allied disorders
726.3	Enthesopathy of elbow region
726.31	Medial epicondylitis
726.32	Lateral epicondylitis
726.4	Enthesopathy of wrist and carpus
727.0	Synovitis and tenosynovitis
727.03	Trigger finger (acquired)
727.4	Ganglion and cyst of synovium, tendon, and bursa
727.61	Complete rupture of rotator cuff
736.0, 736.1, 736.2	Acquired deformity of forearm, mallet finger, and other acquired deformities of the fingers
810, 811, 812, 813, 814, 815, 816, 817, 818, 819	Fractures of clavicle, scapula, humerus, radius and ulna, carpal bones, metacarpal bones, one or more phalanges of the hand, multiple fractures of hand bones, and ill-defined fractures of upper limb
831	Dislocations of the shoulder
840, 841, 842	Sprains and strains of shoulder, upper arm, elbow, forearm, wrist, and hand
880, 881, 882, 883, 884, 885, 886, 887	Open wounds of shoulder and upper arm, upper limb, elbow, forearm, wrist, hand except fingers, fingers, multiple and unspecified open wound of upper limb, traumatic amputation of thumb, other fingers, arm, and hand
885, 886, 887	Traumatic amputations of the thumb, other fingers, arm, and hand
943, 944	Burns of upper limb (including wrist and hands)

There was an 80% increase in amputations ($p < 0.004$), 85% in brachial plexus ($p < 0.035$), 35% in burns ($p < 0.006$), 41% in enthesopathy of the elbow ($p < 0.005$), 194% in lesion of the radial nerve ($p < 0.003$), and 45% in lesion of the ulnar nerve ($p < 0.004$). In contrast, dislocations ($p < 0.004$), fractures ($p < 0.32$), ganglion cyst ($p < 0.004$), and rotator cuff/shoulder syndrome ($p < 0.017$) were significantly more prevalent during the peacetime years (Figure 2). The Air Force data revealed a 52% increase in brachial plexus lesion ($p < 0.005$), 89% in lesion of the ulnar nerve ($p < 0.006$), and 65% in UE tendon rupture ($p < 0.042$) (Figure 3). The Navy data reflect the greatest significant increase in the number of

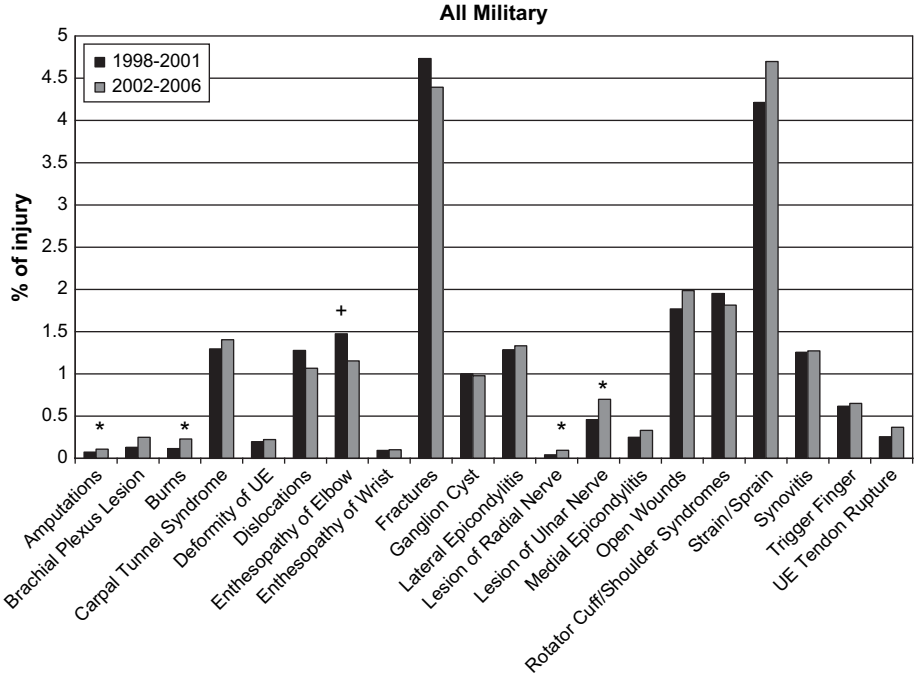

FIGURE 1. *The percentage of upper extremity diagnoses in the military categorized into peacetime years, 1998–2001 and wartime years, 2002–2006. +1998–2001 group incurring more injuries than 2002–2006 group ($p < 0.05$). *2002–2006 group incurring more injuries than 1998–2001 group ($p < 0.05$).*

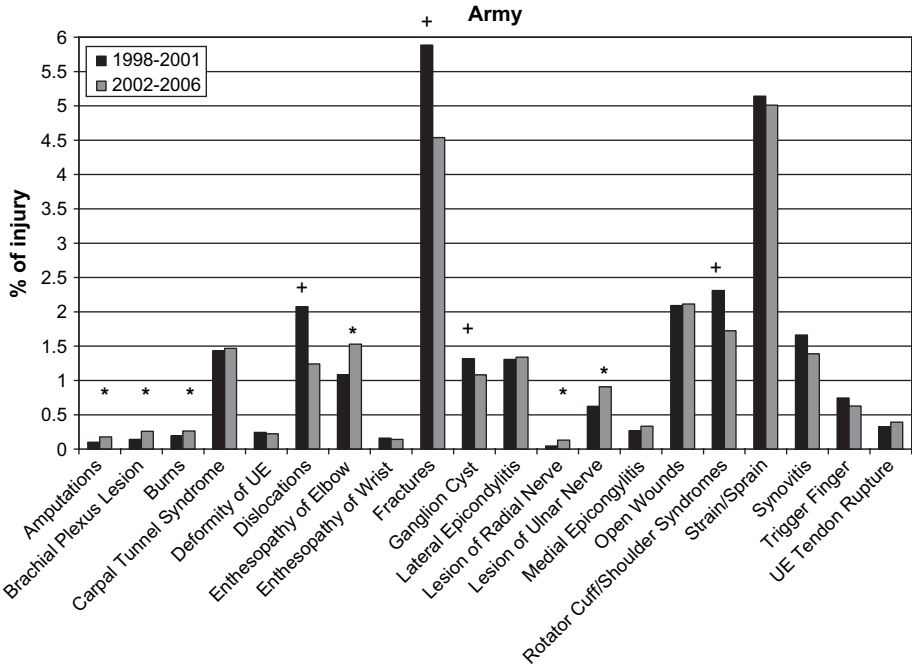

FIGURE 2. *The percentage of upper extremity diagnoses in the Army categorized into peacetime years, 1998–2001 and wartime years, 2002–2006. +1998–2001 group incurring more injuries than 2002–2006 group ($p < 0.05$). *2002–2006 group incurring more injuries than 1998–2001 group ($p < 0.05$).*

UE diagnoses during wartime years compared to peacetime years. There was a 52% increase in brachial plexus lesions ($p < 0.032$), 81% in burns ($p < 0.004$), 42% in dislocations ($p < 0.041$), 108% in enthesopathy of the wrists ($p < 0.045$), 39% in lesions of the ulnar nerve ($p < 0.043$), 76% in medial epicondylitis ($p < 0.001$), and 78% in UE tendon rupture ($p < 0.006$) (Figure 4). In the Marines, there was a 103% increase in amputations ($p < 0.007$), 286% in brachial plexus lesions ($p < 0.009$), 73% in burns ($p < 0.002$), 204% in lesion of the radial nerve ($p < 0.003$), and 53% in medial epicondylitis ($p < 0.039$) during wartime compared to peacetime (Figure 5).

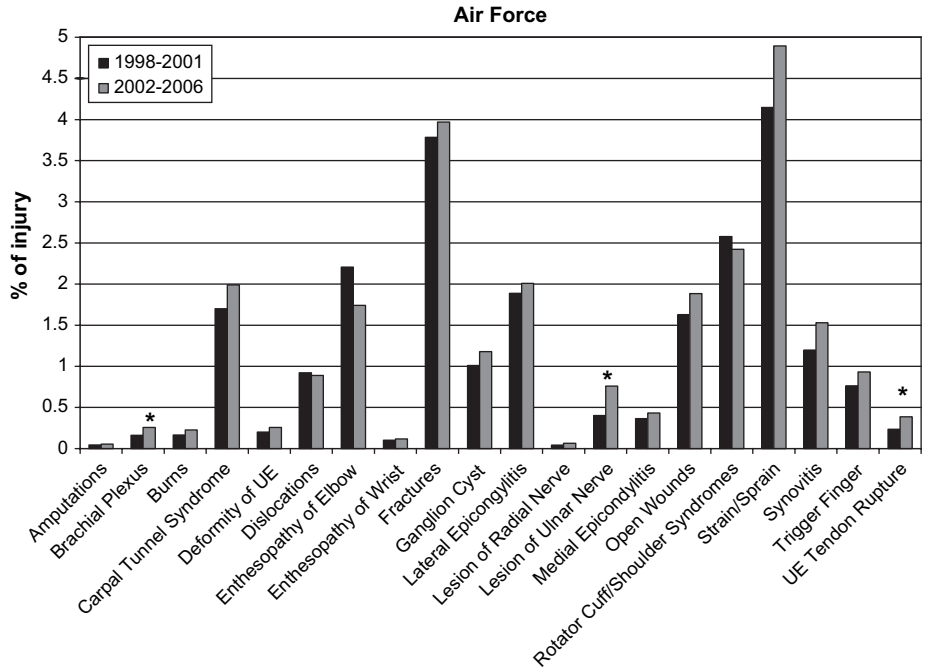

FIGURE 3. *The percentage of upper extremity diagnoses in the Air Force categorized into peacetime years, 1998–2001 and wartime years, 2002–2006. *2002–2006 group incurring more injuries than 1998–2001 group ($p < 0.05$).*

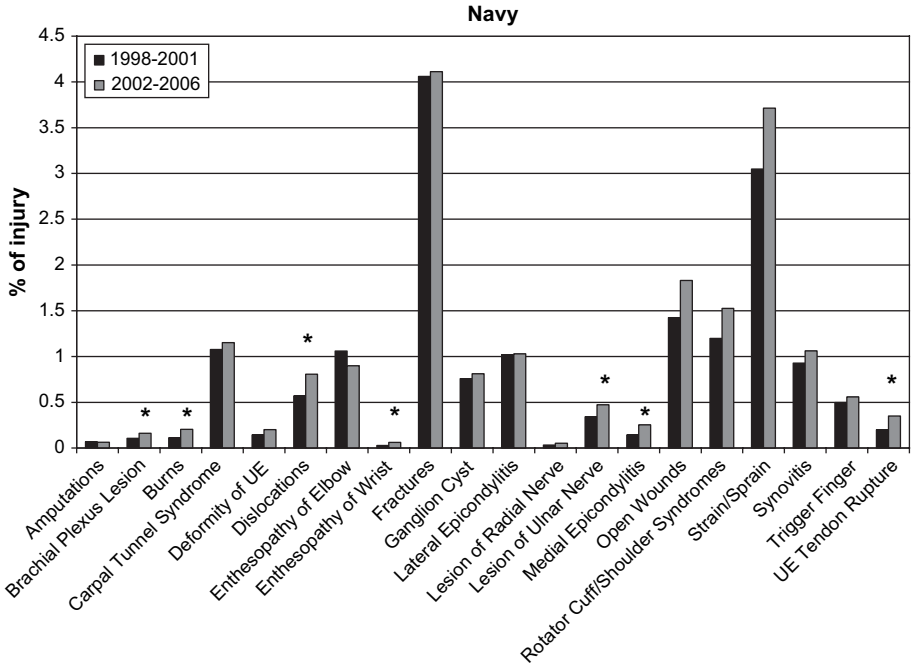

FIGURE 4. *The percentage of upper extremity diagnoses in the Navy categorized into peacetime years, 1998—2001 and wartime years, 2002—2006. *2002—2006 group incurring more injuries than 1998—2001 group ($p < 0.05$).*

DISCUSSION

The major findings of this study were the following: UE injuries from peacetime to wartime increased 3%, and there were significant increases in many types of injuries during wartime across all branches of service. The Army was the only branch of service to demonstrate a significant decrease in any UE diagnoses during wartime compared with peacetime. There were significant decreases in the diagnostic categories of UE dislocations, fractures, ganglion cysts, and rotator cuff/shoulder syndromes. It is not surprising that amputations and burns are diagnosed at a significantly higher rate during wartime given the presence of land mines and other explosives. However, the significant increase of brachial

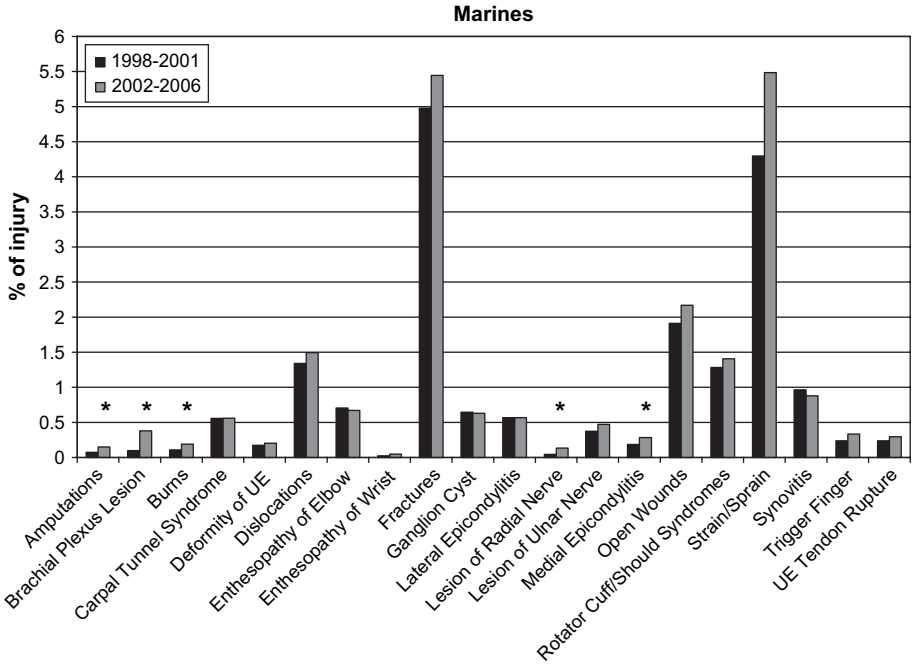

FIGURE 5. *The percentage of upper extremity diagnoses in the Marines categorized into peacetime years, 1998—2001 and wartime years, 2002—2006. *2002—2006 group incurring more injuries than 1998—2001 group ($p < 0.05$).*

plexus lesions for all branches of service, the increase of radial nerve lesions in the Army and Marines, and the increase in ulnar nerve lesions in the Army, Air Force, and Navy warrant further investigation.

Many factors may contribute to the significant increases of brachial plexus lesions and lesions of the ulnar and radial nerve during wartime including explosive devices, gunshots, carrying heavy equipment, wearing the individual body armor, austere sleeping conditions, or performing work-related tasks. Explosive devices and gunshots are a consequence of combat, while carrying heavy equipment and performing work tasks in most cases are preventable injuries.

Documenting the incidence of UE injuries in the U.S. military is essential information for researchers, decision makers, and policy makers who are involved in developing and implementing prevention programs. The results of this study demonstrate that UE injuries vary between branches of service and this knowledge will allow policy makers to tailor programs to the individual needs of the branches of the Armed Forces. In addition, this information will be useful for the military OT in deployed and nondeployed settings. It will allow therapists to staff and equip their clinics appropriately and will also help the deployed OT with planning and packing supplies needed in the theaters of operation. The military educators and the military occupational therapy fieldwork coordinators can also benefit from the results of this study. Historically, education for the military OT has focused on the most prevalent diagnoses seen in the military clinic. As the UE diagnoses shift and become more challenging, it is imperative that the education provided for the seasoned military OT and the military occupational therapy student interns focus on the current clinical environment, which in turn will increase the quality of care.

The results of this study may also provide guidance to commanders. Knowing the incidence and patterns of common UE injuries during wartime will assist and guide commanders on providing relevant training programs focusing on prevention, safety, battlefield treatment, and equipping the SM with additional knowledge and skills, which may increase their performance and decrease their risk of injury on the battlefield. This information will also assist commanders in more accurately identifying the needed medical supplies, developing budgets, and requesting medical personnel staffing in deployed and nondeployed settings.

This study had several limitations in addition to the inherent limitations that accompany using large databases for research purposes. The database queried only included visits from established military medical treatment facilities and outsourced non−Department of Defense clinic outpatient health care provided to active duty SMs. This database does not include injuries sustained or treated at military mobile hospitals in the theater of operations (Iraq or Afghanistan). Thus, any UE diagnoses treated in Iraq or Afghanistan were not included in this analysis unless they were evacuated to a permanent military medical facility or an outsourced non−Department of Defense facility. Another limitation was the inability to determine if the SM sustained multiple injuries. The database only allows for the number of counts in the respective ICD-9 diagnostic code. Information cannot be obtained if that SM was counted for additional diagnostic codes. Specific SM information also cannot be obtained from this database.

The incidence of UE injuries in the U.S military is not well documented. Future research should be prospective in nature and focus on a more in-depth investigation of UE injuries, specifically on the battlefield. Determining the rate and types of UE injuries sustained on the battlefield will provide the evidence needed to effectively equip and staff our deployed units with the appropriate medical professionals.

CONCLUSION

The results of this study validate that UE injury patterns in the U.S military have changed since the beginning of OEF and OIF and that these injury patterns differ between branches of service. Unfortunately, as the war on terrorism proceeds, OT will continue to treat complex UE injuries. It is important that decision makers, policy makers, military occupational therapy educators, line officers, and deployed OTs have a working knowledge of the types of preventable, as well as unpreventable, UE injuries their SM may experience during wartime.

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#1. In the US military during the period 2002-2006 there was approximately a −−−% increase in upper extremity amputations compared to the period 1998−2001
   a. 75
   b. 55
   c. 45
   d. 25

#2. The current wars have seen
   a. more radial nerve injuries than ulnar nerve injuries
   b. more ulnar nerve injuries than radial nerve injuries
   c. a similar amount of radial nerve and ulnar nerve injuries
   d. very few peripheral nerve injuries

#3. In the wars in Afghanistan and Iraq almost −−−−−US military personnel have sustained combat injuries
   a. 100,000
   b. 10,000
   c. 50,000
   d. 30,000

#4. In peace time the most common type of upper extremity injury presenting to US military OT departments is
   a. military training related
   b. covert mission combat related
   c. sports related
   d. digital fractures

#5. The rate of upper extremity injuries and the pattern of injuries in the current war period are very similar to the rate and pattern experienced in Desert Storm and Vietnam
   a. true
   b. false

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